GLOBAL/ORBITAL TRANSPORT (GOT)

October 2, 2001

Dennis Petley
d.h.petley@larc.nasa.gov

Overview

- Assess the potential for providing global transport capability AND access to Low Earth Orbit (LEO) using one common vehicle concept

- Vehicle concept is the booster for a 2-3 stage launch system to deliver passengers and cargo to LEO and a high speed cruise vehicle to provide global access in about three hours

- Neither of these ideas is “revolutionary” in themselves but the idea of combining them in one vehicle is

Potential revolutionary cost benefit:

- Dual use for research, development, and fabrication
- Sharing of infrastructure and operations cost
- GOT would be government / industry joint program

Overview (Continued)

Enterprises involved

- **Code R** (Global/Orbital transportation)
- **Code M** (LEO space infrastructure, supports the HPM)

Current comparison vehicles

- **Global transport**
  - The Concord has a capacity of 100 passengers, cruises at Mach 2 and has a range of 3500 nm.
  - All others are subsonic

- **Access to LEO**
  - The Space Shuttle launches from KSC and has a capacity of 36K lbs to station and 55K lbs to 160 nm East at an operational cost of $10K/lb of payload delivered.
  - All others are expendable

Groundrules of Study

- The global transport vehicle is sized for optimum capacity between 12 and 200 passengers.

- Global transport range of 6500 nm with 3 hours transit time:
  - 6500 nm (90% of market, access to major cities from NY, LA)
  - 8500 nm (100% of market)

- Orbital transport capability to low earth orbit:
  - A Pilot and 7 passengers, a total of 8 people (12x/yr)
  - 20,000 lbs hydrogen/oxygen rocket propellant per week.

- Airbreathing propulsion was considered for the global transport and the first stage of the orbital transport to minimize cost.

- Vehicle combinations to be studied in FY01 were:
  - **Mach 4.5 cruise and 2STO/3STO**
  - **High Mach Cruise and SSTO**

Mach 4.5 Cruise and 2STO

Fuels: hydrocarbon, hydrogen, oxygen (optimize)

Orbiter propulsion: (a) Rocket, (b) rocket based combined cycle (RBCC)

Booster propulsion: After-burning turbojet

Cruise design: Waverider (single propulsion flow-path, low cost)

Orbiter designs: (a) Winged body rocket vehicle, (b) RBCC lifting body vehicle

Booster designs: (a) Waverider with top mounted rocket vehicle orbiter, (b) Waverider with top mounted airbreathing orbiter, (c) Tandem Waveriders with center mounted airbreathing orbiter.

MACH 4.5 WAVERIDER CRUISE VEHICLE

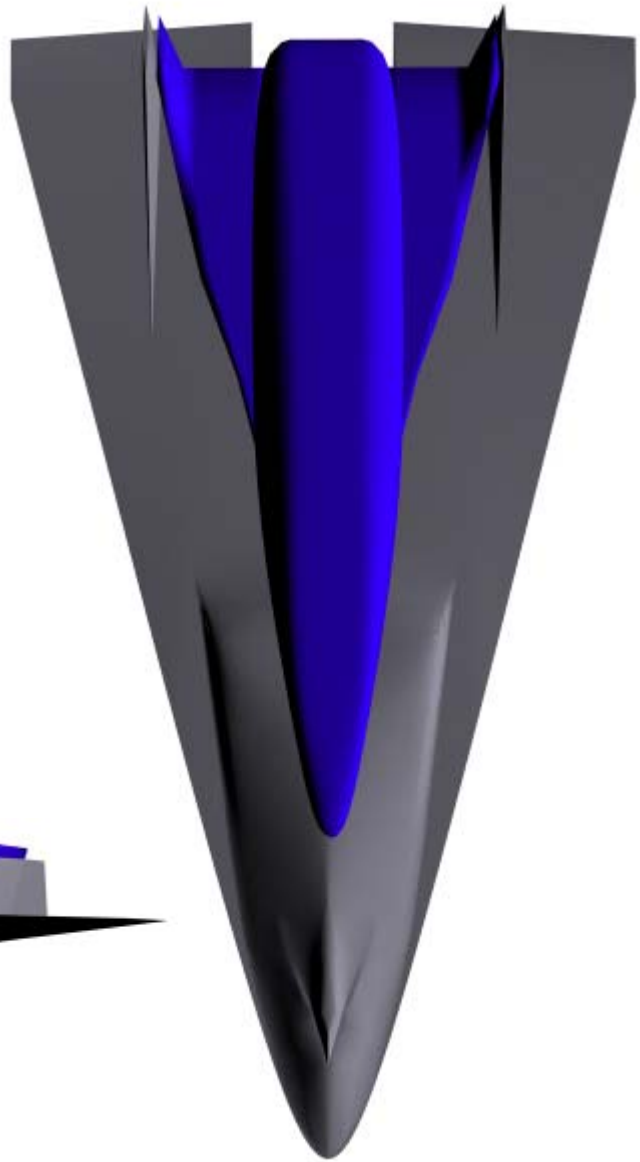
RESULTS FOR THE MACH 4.5 CRUISE MISSION

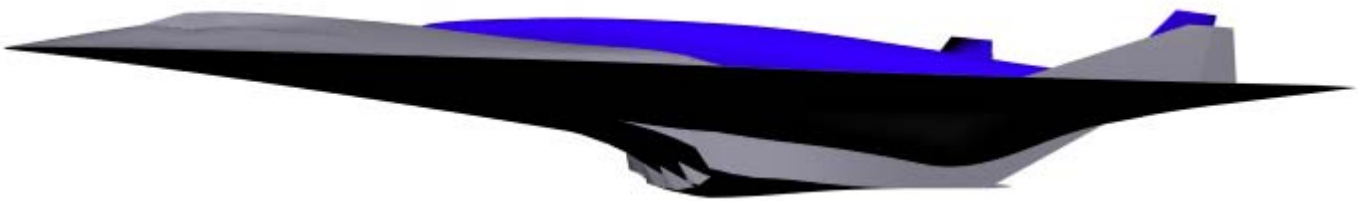
- **Results for 12 passengers:**
  Length = 149 ft.
  Dry weight = 153,000 lbs.
  Gross weight = 829,000 lbs.
  Thrust at take-off = 684,000 lbs.

- **Results for 24 passengers:**
  Length = 152 ft.
  Dry weight = 158,000 lbs.
  Gross weight = 865,000 lbs.
  Thrust at take-off = 748,000 lbs.

2STO with Top Mounted Rocket Orbiter

Length Ratio = 1.5





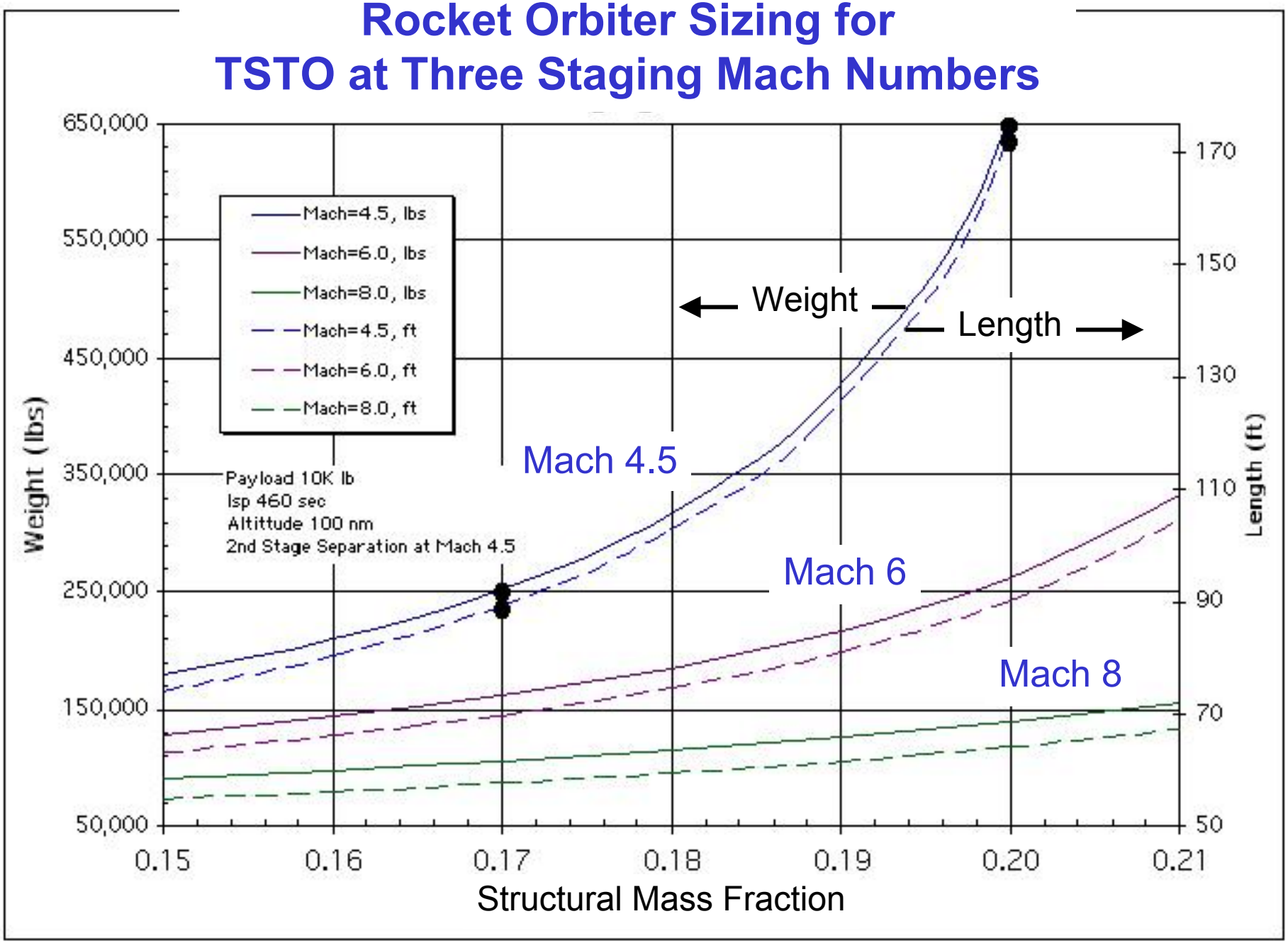
STRUCTURAL MASS FRACTIONS (SMF) FOR ROCKET VEHICLES

- The Access-To-Space study assumed a SMF of **14.5%** for a reusable rocket vehicle, the low end of the range.

- Reusable rocket vehicles in the current study used a SMF from **17-20%** based on the following design features:
  - Composite structures
  - Al-Li tanks
  - Metallic TPS
  - Lightweight SSME derivative

- Expendable rocket vehicles which have been built and flown have a SMF range of **12-14%**.

Rocket Orbiter Sizing for TSTO at Three Staging Mach Numbers



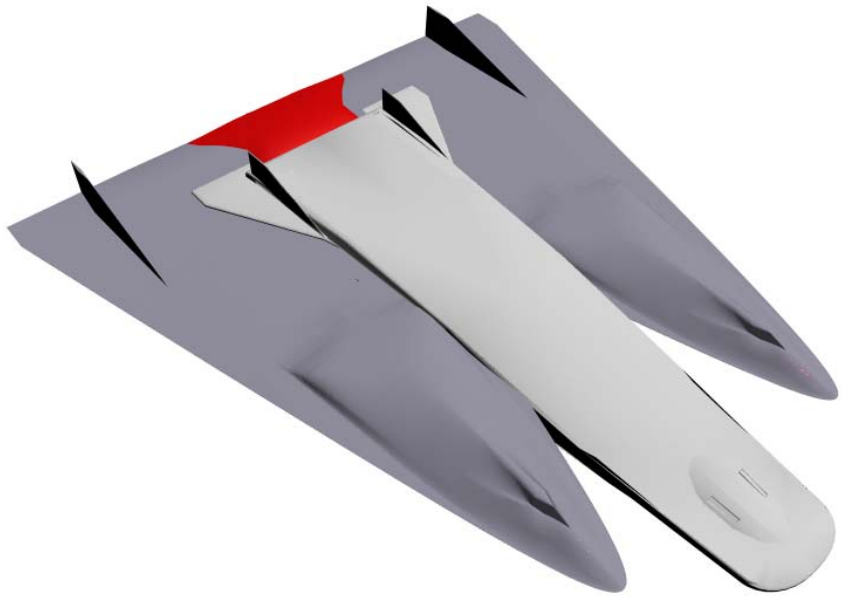
SIZING OF 2STO VEHICLE WITH TOP MOUNTED ORBITER (10,000 pound payload)

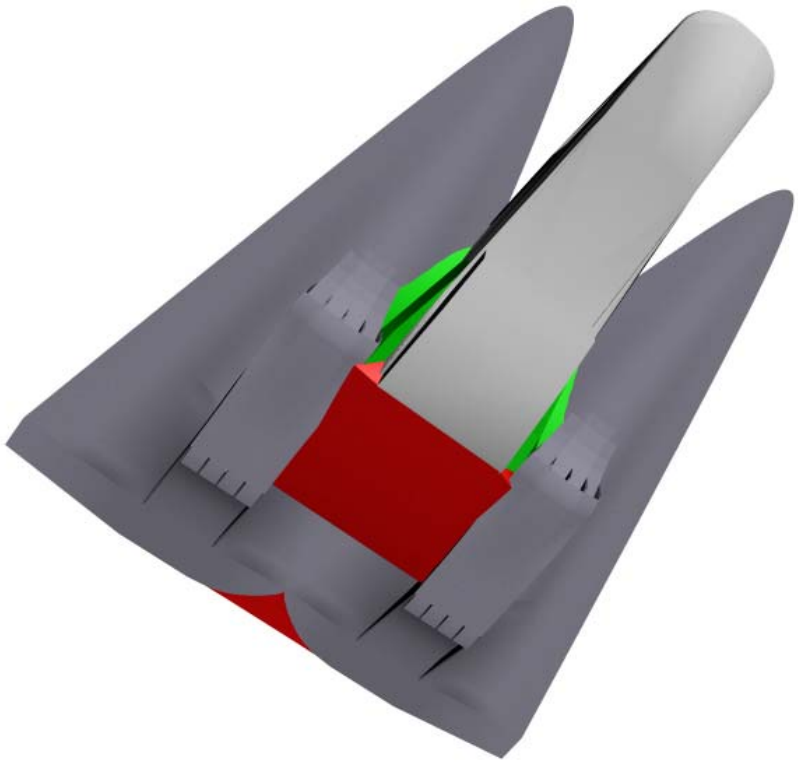
- The waverider vehicle was scaled for top mounted rocket vehicle.
- Results were obtained for second stage SMF of 17% and 20%.

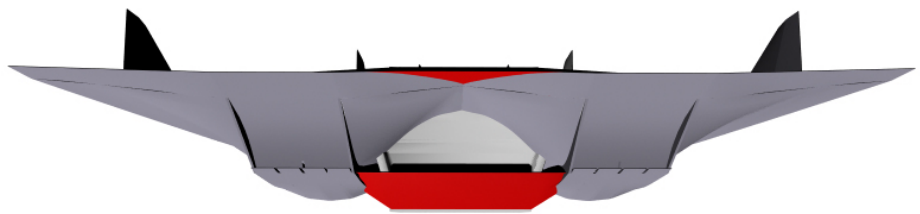
SMF	TOGW	Length
0.17	0.6 mil lbs	**135 ft** (length of MD-11 Transport)
0.20	1.5 mil lbs	**263 ft** (length of A380 Transport)

Compare this to the **24** passenger global transport length of **152 ft.**

2STO with MACH 4.5 Tandem Boosters





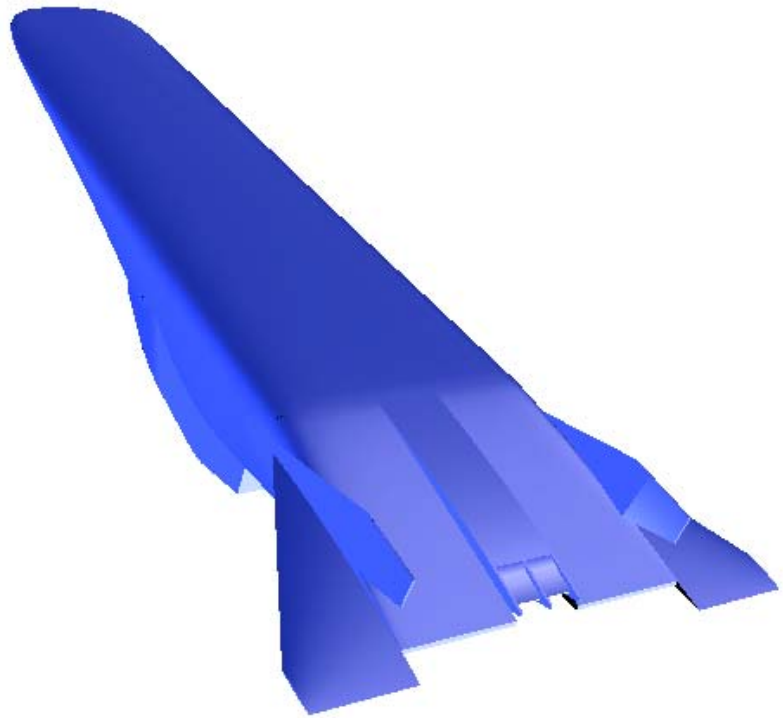


High Mach Cruise and SSTO

Fuels: hydrogen, oxygen

Propulsion: TBCC with turbojet over and ram-scramjet under

Cruise and SSTO design: TBCC Lifting body



Adapt An SSTO Vehicle for Global Transport

- Assumption: at the same physical size that closes for the access to space mission, accelerate to Mach 10, throttle back to cruise, and descend using the same total useable propellant volume.
- Passenger payload module could be 15x15x30’

  (43 passengers and 5 crew, 38K lbs)
- TOGW would be 1.0 million minus O_2 weight plus extra payload weight, about 750-800 klbs

Results

- At 800 klbs TOGW, well over 9000 nmi range can be achieved.

Caveats:

- Minimum cooling phi requirements will limit cruise velocity to Mach 6 to 8.
- Reduced power / unpowered aerodynamics need to be reviewed.
- Weights and packaging need to be reviewed.

Technologies

Enabling For Concept Vehicles

- **Mach 4.5 turbojet**
- **Mach 4.5 staging system**
- **Hot integral tank structure**
- **Purged, mechanically attached TPS**
- **Cold integral hydrogen tank structure**
- **Ramjet/scramjet propulsion**
- **Autonomous GPS flight control**

Yet To Be Studied

- Light weight structural materials
- Ultra-high temperature ceramics
- Air condensing system
- System to separate oxygen from air
- MHD augmentation of propulsion
- Morphing structure
- Pulse detonation engines
- Launch assist
- Wing tanks for cryogens
- Nuclear propulsion

Summary

The mission can be accomplished with:

- A Mach 4.5 global transport / 2STO or 3STO
- A Mach 6 to 8 global transport / SSTO

FY02 Plans:

- Update analysis of global transport
- Update analysis of 2STO / 3STO
- Estimate cost advantage for dual use GOT
- Assess environmental impact for global transport
- Estimate technology sensitivities